SOUTHERN INSECT MANAGEMENT LABORATORY

USDA/ARS

Stoneville, Mississippi

Annual Report on Progress (CY 1995)

and

Plans (CY 1996)

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I. INTRODUCTION:

This report summarizes progress made on various research objectives in 1995 and presents plans for 1996.

Many of the results are preliminary and others are being released through established channels. Therefore, this report is not intended for publication and should not be referred to in literature citations.

The intent of this report is to give the reader an overview of Southern Insect Management Laboratory (SIML) research activities. These activities (progress and plans) address the laboratory and unit missions (listed on pages 4-6).

SIML activities are centered around seven research thrusts, which reflect present CRIS work units. These are:

1. Biological and genetic control and area-wide management of crop insect pests, emphasizing *Heliothis/Helicoverpa*;

2. Population ecology of insect pests for integrated control/ management systems;

3. Biology, ecology, behavior, and biological control of plant bugs, cotton aphids, and sweetpotato whitefly;

4. Strategies for managing crop insects, emphasizing the cotton agroecosystem and pesticide effectiveness;

5. Integrated control of pecan pests;

6. Host plant resistance in soybean pests; and

7. Rearing of eight insect species in support of research around the world.

This report is divided into four sections:

1. Report on research progress in CY 1995;

2. List of publications including those in press and accepted for publication.

3. Other indicators of progress such as presentations and papers in manuscript; and

4. Plans for CY 1996.

In each section, items are arranged by researcher (in alphabetical order of lead scientist; the name of lead scientist and cooperating and/or collaborating researchers are provided for each item). If the reader has questions pertaining to the item, he/she should contact the individual scientist or laboratory director.

II. MISSION STATEMENTS AND STAFF:

SOUTHERN INSECT MANAGEMENT LABORATORY
ARS/USDA, Mid South Area
P. O. Box 346
Stoneville, Mississippi 38776
Telephone: Comm: 601-686-5231
FTS: 700-497-2231
FAX: 601-686-5421

OFFICE OF LABORATORY DIRECTOR

MISSION:

The mission of the Southern Insect Management Laboratory is to conduct fundamental research on the biology, ecology, and rearing of field crop and pecan insect pests and their natural enemies; develop innovative biological, genetic, cultural, and chemical methods for suppressing insect pests; and integrate this knowledge into insect management systems, with emphasis on area-wide methods for *Heliothis/Helicoverpa*. A goal of this laboratory is to develop new and improved insect pest suppression strategies, including improvements in pesticide effectiveness, for population management approaches to improve crop production efficiency. Exotic organisms are received and cleared through the Stoneville Research Quarantine Facility for biological control of insects and weeds. Exotic predators and parasites are released and evaluated for establishment on field crop insect pests.

ARS PERSONNEL:

D. D. Hardee, Laboratory Director
- T. G. Burton, Secretary AO
  - L. E. Taylor, Office Automation Assistant
- W. W. Bryan, Entomologist/Quarantine Officer
  - S. B. Ginn, Biological Science Laboratory Technician
- R. L. Ford, Acting-in-Charge (Insect Rearing)
  - H. E. Winters, Biological Technician (Insect Rearing)
  - G. J. Patterson, Insect Production Worker
- J. D. Warren, Engineering Technician (Shop)

SOUTHERN INSECT MANAGEMENT RESEARCH UNIT

MISSION:

To develop new knowledge on the biology of field crop insects for development of new and improved control tactics and to establish fundamental principles for encouraging and using natural enemies more effectively. To develop and integrate insect suppression strategies into field crop and pecan systems that minimize the cost of plant protection, yet are ecologically acceptable. Specifically:

1. Elucidate the efficacy of indigenous predators and parasites, particularly those attacking the bollworm, *Helicoverpa zea*, and tobacco budworm, *Heliothis virescens*.

2. Research and develop methods for augmenting parasite populations in management of insect pests of field crops, particularly use of *Microplitis croceipes* and other parasitoids for control of *Heliothis/Helicoverpa*.

3. Develop new knowledge on biology and behavior of *Heliothis/Helicoverpa* spp. and beet armyworm, including use of entomopathogenic viruses in management of the latter.

4. Conduct basic biological and ecological research on plant bugs, particularly the tarnished plant bug, *Lygus lineolaris*, cotton aphid, *Aphis gossypii*, and the sweetpotato whitefly, *Bemesia tabaci*.

5. Develop monitoring and predictive technology through quantitative population ecology for field crop insect pests, particularly bollworm/budworm, tarnished plant bug, and cotton aphid.

6. Assess the role of early season host plants in the buildup of *Heliothis/Helicoverpa*, beet armyworm, and tarnished plant bug populations and devise new and innovative tactics for suppressing these populations, including use of entomopathogenic viruses in area-wide management of these pests.

7. Develop chemical/biorational control tactics for use in integrated systems.

8. Develop chemical, biological, and other nonchemical methods for control of insect and mite pests of pecans. Evaluate selections and native pecans for yield and adaptability to the mid-south.

9. Locate, develop, and evaluate soybean cultivars resistant to insects.

ARS PERSONNEL:

D. D. Hardee, Research Leader, Laboratory Director
(Supervisory Research Entomologist)

M. R. Bell, Research Entomologist
R. W. Hoagland, Biological Science Technician

G. W. Elzen, Research Entomologist
L. C. Adams, Biological Science Technician

D. E. Hendricks, Research Entomologist
D. W. Hubbard, Biological Science Technician

L. Lambert, Research Entomologist
W. L. Solomon, Biological Science Technician

W. P. Scott, Research Entomologist
D. A. Adams, Biological Science Technician

M. T. Smith, Research Entomologist
F. M. Williams, Biological Science Technician

G. L. Snodgrass, Research Entomologist
Vacancy, Biological Science Technician

III. SUMMARY OF RESEARCH PROGRESS FOR CALENDAR YEAR 1995:

A. *NARRATIVE:*

1. In-House

A study was began to evaluate the effects of parasitization on lectin and catecholamne levels in corn earworm larvae, *Helicoverpa zea*. The CEW larvae were parasitized using *Microplitis croceipes*. **[O. A. Adeyeye (Duquesne University), W. W. Bryan]**

As in 1994, over 8 million cotton bollworm larvae were grown and used to produce enough of an EPA-labeled insect virus to treat 215,000 acres to evaluate the effect of treating early season hosts of the tobacco budworm as an area-wide pest management procedure. The virus was applied under a contract using private aircraft with global position systems for guidance to treat the same 311 square mile area with the virus as was treated in the 1994 test. This year, the virus was applied from 5 May through 10 May 1995, approximately one week later than in 1994 when it was applied between 28 April and 3 May. It was disappointing that Dr. Snodgrass' data did not show any differences in the numbers of larvae or eggs on the cotton; however, we did see positive indications of this year's effect that may be compared to 1994. First, when larvae were collected from early season weeds in 1994 (tobacco budworm and bollworm), 85% of those collected died from virus infection. Those larvae were collected from only 2 locations for a total of only 57 larvae, and they were collected at 3 days after treatment. In comparison, a total of 398 tobacco budworm larvae were collected from weed hosts in 1995, and they were sampled from 21 different spray areas (8000 acres per area) and at various times. The mortality of these larvae averaged 54% due to virus infection, and 100% of those collected immediately after the application were diseased. By the next week, the percentage infected larvae decreased - but by that time, many of the infected larvae would have been dead and therefore would not have been collected. The persistence of virus infection for the following 10 days could indicate the transmission from dying, diseased larvae to new larvae on the hosts. In 1994, overall counts of tobacco budworm and bollworm moths in the treated area between 10 June

and 22 August averaged 53% less than the numbers in traps in the untreated areas, and the data indicated the bollworms were the most affected. In 1995, the average numbers of both bollworms and budworms trapped in the treated area were 60-70% less than the number in the untreated area, with an average total reduction of 66%. We expected the effects of the early virus treatment to be expressed during the emergence of moths in the June generation. That is what is indicated by the 1994 *H. virescens* trap captures (ca. 6 June through 4 July). The 1995 trap data not only indicate the reduction in June, but also suggested continued reductions through the July population. This was also what Jane Hayes suggested regarding her evaluation of the 1991 test. Although we had 4 areas picked for possible cage evaluations as in previous years, circumstances resulted in no cage data of any value from this year's test. **(M. R. Bell)**

The baculovirus from the beet armyworm was produced in the lab using larvae supplied by the Gast Rearing Laboratory and the SIML insect rearing. Field tests were then conducted in Texas to compare the effectiveness of a commercial preparation and a local isolate of the nuclear polyhedrosis virus, and the effect of formulation and application in the level of control obtained. These studies showed that 78 to 92% of larvae on cotton were infected when the virus was applied using ground equipment compared to 52% when it was applied by aircraft. Results further showed the local isolate equal to the commercial virus, and that the addition of an oil-sugar formulation increased the percentage of larvae infected in the field. Tests were continued in the laboratory to examine new methods of producing entomopathogenic viruses for field application. The efficacy of producing the baculovirus from the beet armyworm was demonstrated, although additional information is needed prior to developing large scale methodology. **(M. R. Bell)**

A *Microplitis croceipes* rearing enhancement study using *Helicoverpa zea* was completed. The study evaluated three oviposition methods (treatments) used to expose *H. zea* larvae to *M. croceipes* females. The three different oviposition methods evaluated were: (1) A multicellular rearing unit; (2) a 32-cell tray (27 x 15 x 1.5-cm) method which was a clear plastic tray with 32 cells that each contained the Nutrisoy/wheatgerm diet; one larva was placed in each cell and the tray was covered with a paraffin coated plastic sheet; and (3) a tray/cage method which consisted of a modified version of the multicellular rearing unit with another fiber-glass tray that was modified to serve as a lid. The lid had a 25.4 x 27.9 cm area cut in the center; the remainder of the top had rows

of 6.4-mm diameter holes and a 3.2 cm stoppered hole for the introduction of parasitoids. The first two methods were evaluated by holding the trays in large wooden cages (inner dimensions 40.6 x 81.3 x 29.2 cm) with cast acrylic tops (6.4 mm); the cages have organdy in the backs and sides for ventilation. Each cage had a 1.3-cm diameter stoppered hole for the introduction of parasitoids. Three different density levels of *H. zea* larvae were used for each oviposition method tested: 100, 200, and 300, 4 to 5 d old *H. zea* larvae. A total of 10,800 larvae were used in the test. Females aged 6 to 8 d were used for parasitism; the test was replicated 6 times. A split plot, replicated in time, experimental design was used. The results showed method 2 generally gave higher mean percentages of the three methods tested. Cocoon formation: method 2, 60.72%; method 1, 55.50%; and method 3, 47.72%. Total parasitism: M2, 78.89%; M1, 61.94%; and M3, 54.72%. Total mortality: M2, 20.22%; M1, 27.72%; and M3, 37.94%. The 100 density had the higher percentages among the three densities tested. Cocoon formation: density 1, 57.78%; density 2, 54.33%; and density 3, 51.83%. Total parasitism: D1, 68.11%; D2, 65.94%; and D3, 61.50%. **(W. W. Bryan)**

Selected sites in Washington and Bolivar Counties were monitored for the incidence of sterility in the wild tobacco budworm, *Heliothis virescens* (F.), populations. Sites were selected to coincide with release sites of a three year pilot test program to suppress the wild population of *H. virescens*. The pilot test was conducted during 1991-1994. During the 1995 growing season wild males were collected from pheromone traps at three different locations. Two of the sites had been release sites in the pilot test project and a control location from a non-release site. Preliminary evaluations showed 2-4% sterility was found in the release sites. Further evaluations are in progress. **(W. W. Bryan)**

Seven treatments were evaluated for control of the cotton aphid in replicated small plots in cotton. All treatments were significantly more effective than the untreated check, and Karate was less effective than all other treatments except the untreated check. **(G. W. Elzen)**

Eight treatments were evaluated for control of the cotton aphid in replicated small plots in cotton. A pretreatment survey indicated a moderate aphid infestation. In general, treatments which included Provado or Bidrin provided greater control than other treatments, except that Thiodan was more effective than Bidrin after the second application. **(G. W. Elzen)**

Five treatments were evaluated for control of tarnished plant bug in replicated small plots in cotton. The tarnished plant bug population was at a low level when tests commenced. Admire provided control equivalent to Cygon and methyl parathion. **(G. W. Elzen)**

Nine treatments were evaluated for control of tarnished plant bug in replicated small plots in cotton. The tarnished plant bug population was at a low level when tests commenced. Provado and CGA 215944 provided control equivalent to Curacron, Orthene, and Bidrin. **(G. W. Elzen)**

Ovicides, including the newly registered product Provado, were evaluated in field and laboratory bioassay conditions using cotton for control of tobacco budworm. Susceptible and insecticide resistant insects were evaluated. Lower mortality to a pyrethroid in the resistant strain indicated possible resistance in the eggs. Provado, which is targeted at sucking pests, provided acceptable control. **(G. W. Elzen)**

A standard spray chamber bioassay was used to evaluate resistance levels in tobacco budworm, *Heliothis virescens* (F.), to pyrethroid, carbamate, and organophosphorus insecticides and *Bacillus thuringiensis* Berliner during the 1995 cotton season in Washington County, MS. An adult vial test was also used to evaluate the frequency of resistance to a pyrethroid, carbamate, and organophosphorus insecticide. An ovicide bioassay was also run on a susceptible laboratory strain and one of the field collected strains (generation 2). These bioassays evaluated different kinds of resistance and correlations were not always clear due to the expression of different resistance mechanisms in specific life stages. The spray chamber bioassay may have more clearly shown levels of metabolic resistance, while the adult vial test was an indicator of target-site resistance. The data suggested that metabolic resistance is becoming more important in tobacco budworm. Tests did not indicate resistance to *B. thuringiensis*-based insecticides in the tobacco budworm at the present time. The ovicide test indicated possible resistance to pyrethroids in eggs. High levels of resistance in the tobacco budworm to all classes of conventional insecticides remained a problem. Resistance management plans for tobacco budworm should emphasize strategies that involve conservation of all insecticides used against all pests in cotton. **(G. W. Elzen)**

Production of insects for USDA-ARS research by the Stoneville Insect Rearing Unit required maintenance of seven insect species: *Heliothis virescens, Helicoverpa zea, Anticarsia gemmatalis,*

Pseudoplusia includens, Spodoptera exigua, Cardiochiles nigriceps, and *Cotesia kazak*. Support of USDA-ARS scientists at Stoneville and laboratories in Tifton, GA; Mississippi State, MS; College Station, TX; and Weslaco, TX, required production of 314,000 *H. virescens* pupae, 285,000 *H. zea* pupae, 334,000 *P. includens* pupae, 270,000 *A. gemmatalis* pupae, 264,000 *Spodoptera exigua* pupae, 54,763 *Cardiochiles nigriceps* cocoons, 13,735,200 *C. kazak* cocoons, 39,275,000 *H. virescens* eggs, 27,840,000 *H. zea* eggs, 35,222,000 *P. includens* eggs, 17,734,000 *A. gemmatalis* eggs, and 24,000,000 *S. exigua* eggs. Additional research support included mixing, dispensing, and filling 140,200 30-ml plastic cups and 996 3.8-liter multicellular trays with artificial diet. Total diet mixed and dispensed in 1995 was 14,697 liters. Several short courses in insect rearing techniques were given to employees of: Abbott Laboratory, Chicago, IL, and BASF, Greenville, MS. Approximately 150 researchers located in 37 states, England, Canada, and Japan participated in the Cotton Foundation and American Soybean Association Insect Distribution Programs. **(R. L. Ford)**

Comparisons of plots of transgenic cotton (NuCotn 33) from Delta and Pine Land Company (Scott, MS), DP5415 (same as NuCotn 33 without Bt), Coker 312 (background parent of 1994 transgenic line), and MD51 (nectariless, smoothleaf) indicated (1) significantly fewer cotton bollworm/tobacco budworm larvae and lower percent worm damage in NuCotn 33 than all other varieties, and (2) significantly fewer cabbage loopers, saltmarsh caterpillars, garden webworms in NuCotn 33 than other varieties, and (3) approximately 50% as many beet armyworms in NuCotn 33 as in other varieties. Coker 312 had approximately 50% more tarnished plant bugs (TPB) than DP5415 and NuCotn 33 and over twice as many as MD51. These results suggest that the higher numbers of TPB observed in 1994 in the transgenic cotton were due to the Coker background and not the transgenic character. All other insect numbers, cotton characteristics, and yield were approximately equal. **(D. D. Hardee)**

A study of boll weevil emergence and movement of the boll weevil in the mid-delta of Mississippi showed that (1) boll weevils survived the winter of 1994-95 in extremely high numbers, (2) considerable movement of overwintered and first generation boll weevils occurs after bloom as detected by pheromone traps (approximately 50% of the weevils captured during the week of July 3 were first generation), especially 1-3 miles from cotton, and (3) extremely high late season numbers suggest the need for a harsh winter to reduce 1996 numbers. **(D. D. Hardee)**

Beet armyworm surveys to determine seasonal occurrence of beet armyworm moths were conducted as a continuation of the survey in 1994. Traps were set about 2.8 miles apart in a 76-mile line from Hwy 448 west of Shaw to 2 miles south of Valley Park. The trapline traversed 4 counties. Weather conditions were mild in the 1994-95 winter months (December-February) compared with conditions during these months in 1993-94. For example, the lowest soil temperature (2 in. deep) was 39°F on only the night of 5 January 1995, was 43°F for only 3 nights, and was above 47°F during all other nights of these 3 months. Average low air temperatures for the winter of 1994-95 were 4°F higher than the average for the 1993-94 winter. The soil temperature on 11-12 January 1994 dropped below 32°F for two nights. Captures of BAW were tallied weekly from 1 December 1994 to 29 November 1995, and plotted on graphs each week as BAW captured/trap/night in the 30 traps. Captures from 1 December to 28 February 1995, were less than 0.09 BAW/trp/nt. BAW were captured during all 3 winter months, but their activity was hindered when nightly temperatures dropped below 52°F. From 1March to 31 May, captures peaked once the last week of March and once in the middle of May, but both peaks were below 1 BAW/trp/nt. Starting the week of 28 June-5 July (3.48/trp/nt), moth captures increased at a continuous, geometric rate to the maximum seasonal catch of 371.8/trp/nt during the week of 7-13 September. From 14 September-23 October captures decreased at a comparable but inverse rate, to <130/trp/nt on 23 October. By 15 November, average BAW captures dropped to 30.1/trap/night due primarily to the increased frequency of low nighttime temperatures below 40°F. From June to November of 1995, there was only one single peak in captures of BAW, and there were no acute reductions or dips in average numbers that would delineate distinct generation spans. Condition and apparent age of the moths captured during the growing season indicated that they were mixed ages and from a population matrix of interlaced generations. Ancestral lines of these moths probably were the larvae and moths that feed on wild host plants in October-December 1994 and had survived the 1994-95 winter. **(D. E. Hendricks)**

For the first time in the Delta, a liquid formulation of a single pheromone chemical was developed and applied aerially (Ag Tractor 400) for the purpose of disrupting tobacco budworm and bollworm mating behavior and suppressing populations. These applications were made on 90 A of cotton and surrounding insect host plants. The single pheromone was dispensed on 9 June, 14 July, and 10 August 1995 at 10 grams, 5 grs and 5 grs per acre, respectively. Inspections made of 250 cotton plants 5 and 9 days after the 9 June

and 14 July treatments showed no damage of the squares or blooms caused by tobacco budworms and bollworms. No TBW/BW larvae were found during these inspections. Also, from 2 to 10 lady beetles (adults and larvae) were found per plant during these inspections. Numbers of moths captured in pheromone traps dropped significantly after each treatment for at least 7 days, i.e., from 31-42/night before treatment to 1-7/night average for 7 days after a pheromone treatment. Results were encouraging while indicating that the treatments effectively blocked chemical communications between the genders and reduced their chances of reproduction. Overall populations of tobacco budworms and bollworms were relatively low during the early 1995 growing season. **(D. E. Hendricks, J. E. Mulrooney, R. A. Wesley)**

Surveys of bollworm and tobacco budworm moth populations using replicated installations of 30-in. diam. pheromone traps baited with appropriate pheromone baits showed that moth catches from clusters of 3 to 4 traps set 50 ft apart at 3 different field locations represented true population fluctuations. Cluster of traps nearly eliminates the daily variability in captures of moths caused by unique environmental conditions found at sites where single traps might be installed. These unique conditions, such as different vegetation types or soil moisture levels near a single trap, may vary greatly within a single County or from one side of a cotton field compared with another side. Significant oviposition on cotton preceded, by 3 days the sharp increase in moth captures in traps at the beginning of each moth flight during the season. **(D. E. Hendricks)**

Population density profiles, based on captures in traps (baited with pheromone) and set in three locations as in previous years, were plotted for the 1994-95 winter months and from January-November 1995. Variations in rainfall and soil and air temperatures were also plotted and compared with captures of both tobacco budworms and bollworms. The graphs showed 5 distinct peaks in captures of tobacco budworm moths and 4 peaks in captures of bollworms. Wild geranium and crimson clover supported the first 2 generations of tobacco budworms and bollworms. Velvetleaf supported the 1st to 3rd generations of budworms. Corn and soybeans supported the 2nd and 3rd generations of bollworms. Plots of weather records showed that the low air and soil temperatures during December 1994-February 1995 were unusually warm. The lowest average air temperature was 35°F, occurring in January, and the lowest average soil temperature was 46°F also in January 1995. Temperature of soil at depth of 2 in. dropped to the low of 31°F only during nights

of 16-17 February. Rainfall through the winter months was typical for the Delta area until the last of June. From 10 July to the end of the growing-season, rainfall amounts were far below average, and daytime temperatures averaged 5 to 6 degrees above normal reaching 100°F or more during some days in July, August, and September. High temperatures and little rainfall resulted in drought conditions during the cotton growing season, and there generally was a shortage of vegetation and blooms that would support high populations of budworms or bollworms. Cotton development was stressed during the 3 months critical for square and boll formation. Peak numbers of tobacco budworms and bollworms captured in late August and September averaged 100 to 150 moths/trap/night lower than in previous years. These moderate capture levels were attributed to the scarcity of vegetation and blooms preferred by both budworms and bollworms, and this shortage was undoubtedly caused by the drought conditions. **(D. E. Hendricks)**

Evaluations were continued of twelve insect resistant soybean genotypes with different maturity dates to determine if resistance levels decrease during the fruiting phase or if later maturing genotypes develop higher levels of resistance. All genotypes have essentially the same level of resistance before fruiting. After the onset of fruiting the later maturing genotypes appear to have a higher level of resistance than earlier maturing genotypes. The studies are being conducted in a large field cage utilizing laboratory-reared insects and are to be repeated for several seasons. **(L. Lambert)**

Studies were continued to evaluate the USDA-ARS soybean germplasm collection for resistance to soybean looper and velvetbean caterpillar. In field cage evaluations of 1200 accessions, several genotypes were identified with high levels of resistance to foliar feeding by soybean looper or velvetbean caterpillar. The resistant accessions will be further evaluated and used in a breeding effort to develop soybean cultivars with high levels of resistance to insects. **(L. Lambert)**

Studies were continued to determine the influence of irrigation of soybean on the development of soybean looper populations and the subsequent impact on yield. Due to heavy rains during critical periods, no data were obtained. **(L. Lambert, L. G. Heatherly)**

Studies were continued on the inheritance and development of resistance to foliar feeding insects in soybean and to develop high yielding, insect resistant, group IV & V soybean cultivars. All breeding lines were moved ahead one generation. **(L. Lambert, J. Tyler)**

Continued to develop optical and acoustical studies for determining behavior of soybean damaging insects. Equipment critical to conducting these studies has been obtained. **(L. Lambert)**

Conducted a study to evaluate a gonad-specific virus of the corn earworm. This study is to be repeated. **(L. Lambert, A. Raina)**

Initiated research to identify resistance in cotton to foliar feeding by beet armyworm. This study will require two or more seasons to complete. **(L. Lambert, W. R. Meredith)**

Participated in annual evaluation of the Regional Host Plant Resistance Nursery of soybean for resistance to foliar feeding insects. Several genotypes in the nursery exhibited high levels of resistance to foliar feeding insects. **(L. Lambert)**

Spray table and small plot studies were conducted with Provado (Bayer) and Fipronil (Rhone Poulenc) on tarnished plant bugs and boll weevils. Three formulations of Fipronil showed excellent activity on both plant bugs and boll weevils in spray table tests. Small plot tests indicated that Fipronil (two formulations) and Provado were highly effective on a resistant population of plant bugs. **(W. P. Scott, G. L. Snodgrass)**

A large field plot study to compare methods of sampling (sweep net, drop cloth, and visual) and thresholds recommended in the Insect Control Guide were evaluated in Sure Grow 501. Extremely low populations of plant bugs occurred in 1995. **(W. P. Scott, G. L. Snodgrass)**

A large field plot study to evaluate seed, in-furrow and sidedress treatments on early season insect populations and yield was evaluated. Heavy populations of the cotton aphid were present in most plots by June 30. Temik in-furrow and sidedress (0.60 + 1.5

lbs AI/acre) was the most effective treatment in reducing aphid populations. Highest yields were observed in Temik in-furrow and Temik in-furrow + sidedress treatments. No yield response was observed in either Payload in-furrow or Payload in-furrow + sidedress treatment. **(W. P. Scott)**

The third year of a research project was conducted to determine the utility of a trap crop system designed to intercept migrating stinkbug species as they move from soybean and other host plants into pecan orchards. Results from the 1993 tests showed that: (1) the percent of pecans damaged by stinkbugs decreased significantly with increasing distance into the pecan orchard from the soybean field; (2) sweep net sampling for stinkbug density in pecan trees is inefficient; (3) cultural characteristics of purple hull pea (cowpea) are less desirable than hill pea due to the short window of time during which it is attractive to stinkbugs. Hill pea provided an attractive trap crop for the migrating stinkbugs for a longer period of time than did the purple hull pea. However, field pea is not commercially available. In both the 1994 and 1995 seasons, speckled pea (which is commercially available and has the same desirable cultural characteristics as hill pea), was planted in a continuous strip along the edge of a pecan orchard which borders a soybean field. Only half of the border was planted to peas (treated plot), while the other half remained fallow (check plot). Monitoring of vegetative and fruit phenology in both the soybeans and peas was performed in 1995 and indicated that the peas continued to produce attractive pods until first frost, which coincided quite well with pecan harvest (mid-November). Population density of several stinkbug species was monitored in the soybeans and peas. Sweep net sampling yielded less than satisfactory results in 1994 when compared to the drop cloth method. In 1995, the drop cloth method enabled detection of peak stinkbug immigration periods into the peas, as well as monitoring of the development of their offspring. Control of stinkbugs within the peas was investigated during 1995. Applications of a mixture of Sevin and Phaser were applied when the late instar stinkbugs reached a high proportion of the total population based upon our twice-weekly drop cloth monitoring within the peas. The objective was to kill the offspring of the immigrating stinkbugs prior to their development of wings and their potential emigration out of the trap crop and into the test orchard. Pre- and post-treatment monitoring of stinkbug population levels indicated an acceptable level of stinkbug control. The 1994 nut harvest yielded little or no measure of trap crop efficiency based upon nut damage due to the lack of nuts available at harvest. This resulted from the extremely large numbers of birds which immigrated into the orchard

approximately 2-3 weeks prior to harvest and removed what would have otherwise been an adequate crop for evaluation of stinkbug damage. In 1995, however, nuts were harvested earlier by hand picking immediately prior to and during early shuck split. This was designed to acquire nuts prior to the immigration of birds into the orchard. Although statistical analysis has not as yet been performed, average stinkbug damage in the trap crop area (% whole nuts & % kernels with stinkbug feeding) was reduced by ca. 44-56% (number of stinkbug feeding sites on the kernels were also reduced by ca.64%) when compared to the non-trap crop control area. Therefore, results are very encouraging. Effort was made in the development of an improved method for evaluating stinkbug damage and results appear promising. Efforts are also in progress to relate this more accurate measure of stinkbug damage to the damage estimate methods currently utilized by growers, buyers, and processors. This should enable a more accurate and fair measure of damaged nuts. Finally, the 1995 tests supported the 1993 data in showing that the percent of pecans damaged by stinkbugs decreased significantly with increasing distance into the pecan orchard from the soybean field. This information should prove useful in the monitoring and/or controlling of stinkbugs, where border trees may be utilized as a "trap crop" and spot treated. The 1995 tests also supported the 1993 data in showing a certain level of cultivar preference by the stinkbugs. **(M. T. Smith, G. L. Snodgrass, T. Jenkins, B. Horton, M. Hughs)**

Research was continued on the evaluation of the hickory shuckworm sex pheromone formulation and the development of guidelines for its proper use. All tests are being conducted at three locations across the pecan belt of North America in order to obtain results under different environmental conditions, management systems and shuckworm pressure: (1) Camargo, Mexico represents an arid dessert environment in which irrigation is essential but limited, where pesticides are utilized under a narrow profit margin, and where shuckworm populations can build to enormous levels; (2) the Mississippi Delta orchard represents a hot and humid environment where irrigation is desirable but is not present, where the orchard is maintained under a biological control, non-pesticidal management program, and where shuckworm populations are high in early season and relatively low to intermediate in late season; and (3) the central Georgia orchard also represents a hot and humid environment where irrigation is desirable but is present, where the orchard is under a more intensive management program, and where shuckworm populations tend to be high in early season and quite variable in late season. Results from the preliminary field studies

in 1993 indicated that the hickory shuckworm may not be uniformly distributed within a pecan orchard. Therefore, more definitive investigations were performed in 1994 and 1995 with respect to the spatial and seasonal distribution of the hickory shuckworm moth within pecan orchards as determined by pheromone trap catch. Although data collection is still in progress at the time of this report, this new information will be used to determine the appropriate time to initiate and terminate shuckworm monitoring, as well as the appropriate number of pheromone traps per unit area that will provide a reliable estimate of moth presence and density. Weather data are also being collected at each site in order to correlate shuckworm population trends with key climatic parameters. Eventually, population level thresholds, which undoubtedly vary as a function of nut phenology, will be developed. **[M. T. Smith, Carroll Yonce (USDA-ARS), Salvador Galindo (pecan grower), Jeff White & Steve Whitesides (Ecogen)]**

Preliminary mating disruption investigations of hickory shuckworm were initiated in 1994. Two formulations of the disruptant were prepared: spirals and a sprayable. Development of a suitable sprayable formulation of the disruptant was obtained in 1994. However, due to the very low shuckworm population levels in the test orchards during 1994, coupled with the suspect pheromone lure formulation, mating disruption efficacy data from 1994 were questionable. Mating disruption tests conducted in 1995 utilized the spirals. Although data have not been analyzed to date, the data appear to strongly indicate that it is possible to shut down pheromone trap attractancy to male moths by the deployment of mating disruption spirals in the upper and lower areas of the pecan tree canopy. This occurred at all three test orchards, which were under differing shuckworm population pressures. Data were also obtained in an "Aging" study of the mating disruption spirals in order to determine the expected longevity of their efficacy. Analysis is in progress at the time of this report. Field studies will be repeated in 1996, but with the additional objective of improving the method of application/deployment of the mating disruptant, as well as methods to minimize its cost. This will include the evaluation of a sprayable formulation relative to the traditional spirals. **[M. T. Smith, Carroll Yonce (USDA-ARS), Salvador Galindo (pecan grower), Jeff White & Steve Whitesides (Ecogen)]**

Results from the 1993 pheromone formulation field studies provided evidence suggesting increased attractancy of the commercial lure for shuckworm by the addition of one of the two new compounds isolated in 1992. The 1994 field studies provided evidence that one

of the new formulations was significantly more attractive than the commercial lure. A new experimental procedure was also investigated in which each treatment was placed into every test tree. This appeared to offset the problems associated with shuckworm clumping within an orchard, while not resulting in problems associated with cross-contamination of formulations. The 1995 formulation field studies have not as yet been analyzed. However, it appears that there was little difference in attractancy among the formulations tested. This discrepancy with our 1993-94 data may indicate that the degree of attractancy may be greatly influenced by population density, as well as the degree of clumping (non-random distribution) of the shuckworm. Very careful evaluation of all formulation data will be performed before research direction on formulations is pursued further. **[M. T. Smith, G. Gries (Simon Fraser University), Carroll Yonce (USDA-ARS), Salvador Galindo (pecan grower)]**

Research on factors affecting silverleaf whitefly parasitoid efficacy and evaluation protocol was continued in 1995. Our earlier tests provided evidence for two climatic strains of *Encarsia formosa* (one from Greece and another from Egypt), the most widely utilized and commercially available parasitoid of whiteflies throughout the world. These studies clearly indicated the importance of searching for parasitoids which originate from areas with climates similar to the climates in the targeted areas for release or introduction. As a logical progression to these studies, investigations of the effect of host plant on parasitoid efficacy were initiated in 1995. These studies have expanded to include two additional strains of *E. formosa* (the commercial strain and the Beltsville strain), and have included a phylogenetically diverse group of economically important host plants: cotton, cabbage, tomato, bean, and cantaloupe, as well as hibiscus and poinsettia. Parasitoid biological parameters being measured include adult longevity, life long fecundity and percent parasitism, as well as parasitoid developmental rate and percent emergence. While *Bemisia argentifolii* 3rd instar nymphs are being evaluated, whitefly eggs and early instar nymphs are also being provided since these life stages are utilized as food by adult parasitoids. Host plant leaf area and hair density is being measured as potential factors which may affect searching efficacy of the adult parasitoids, and therefore the various biological parameters. These studies are in progress at the time of this report, and therefore comment on our findings would be premature. **(M. T. Smith, M. Ciomperlik, J. Neal)**

In concert with these parasitoid evaluations, and as a prerequisite to subsequent field evaluation and release programs, a survey of the whitefly and associated parasitoid species was initiated in Mississippi in 1995. Similar surveys have been conducted or are in progress in other states in the southern U.S. Much effort was made to establish and coordinate collection of whitefly infested sample leaves from throughout the state, with ARS, APHIS and the Mississippi State University Agricultural Extension Service (county agents) representing the principle participants. To date, whiteflies have been collected from 35 host plant species in 18 counties. Among the host plants are 2 field crops (cotton and soybean), 15 vegetables, 11 ornamentals, 3 herbs, as well as 2 weeds. Although identifications are only tentative, whitefly species appear to include: bandedwinged whitefly, greenhouse whitefly, silverleaf whitefly, and sweetpotato whitefly. Parasitoids have been collected from 21 plant species in ca. 30% of the samples collected. Parasitoid identifications have not as yet begun due to the challenges associated with resource availability and taxonomic expertise. This survey will continue throughout the year and until at least December 1996. **(M. T. Smith, M. Allred, M. Ciomperlik, B. Layton, R. Snyder, S. Nakahara, G. Evans)**

Efforts were initiated on two additional fronts: (1) collection and preservation of specimens of the 4 *E. formosa* strains for genetic evaluation in cooperation with Drs. C. LeVesque and T. Perring (UCR); and collaborative efforts with Dr. Regina Vilarinho de Oliveira (EMBRAPA, CENARGEN, Brasilia, Brazil), where the primary object will be to explore for and evaluate New World parasitoid species in Brazil for control of *B. argentifolii.* **(M. T. Smith)**

Cotton fields located in 1600 square miles of the Delta were sampled weekly for bollworm and tobacco budworm eggs and larvae during June and July 1995. The fields were located in 4 areas (each ca. 400 square miles) of which 3 areas were checks. The fourth area received an aerial application of an insect virus to all wild host plants in the area in early May to kill first generation bollworm and tobacco budworm larvae found on them. Each of the 4 areas were divided into quadrants and the location of cotton fields in each quadrant recorded. Fields were sampled by whole plant examinations in young cotton. Sampling changed to visual searches of terminals and fruit and foliage in the upper half of each plant when the cotton began to square. Each field was sampled by 2 people and in each sample 10 plants were examined. Fields were classified as small, medium, or large and 20 samples (10 per

observer) were taken in small fields while 40 samples (20 per observer) were taken in medium and large fields. All eggs and larvae found were taken back to the laboratory for rearing and species identification. In each check area, 5 fields were picked at random from each quadrant (20 total) each week and sampled. In the single treated area 6 fields (7 in one quadrant, 25 total) were picked at random each week from each quadrant and sampled. Data entry from this test has been completed and checked for errors. This entailed entry of approximately 20,000 lines of data. Statistical analysis was completed in October. No significant reduction in bollworm or tobacco budworm populations in the treated area was found. Populations of both pest species were low in the treated and untreated areas which made the test hard to evaluate statistically. **(G. L. Snodgrass, M. R. Bell, D. D. Hardee)**

A survey of the Arkansas, Louisiana, and Mississippi Delta was conducted in the spring (April-May) and fall (September-October) to determine how widespread pyrethroid resistance was in tarnished plant bug populations in the Delta. At least 50 adult bugs from each of 71 locations were collected from wild hosts and tested for resistance in the spring, while 72 (mostly the same locations as the spring) locations were sampled in the fall. The bugs were exposed in glass vials (2 adults per vial) treated with 15 µg of technical grade permethrin for 3 hours after which mortality was determined. In the spring survey, 30 locations had susceptible populations (mortalities > 90%), while in the fall survey only 11 locations had susceptible populations. The resistant populations were found scattered throughout the Delta. The greater number of locations with resistant populations in the fall showed the effect of the selection pressure exerted on plant bug populations in cotton with pyrethroids during the growing season. **(G. L. Snodgrass, W. P. Scott)**

On 2 June 1995, a single adult male tarnished plant bug was found that possessed unusual bright red eyes (as compared to normal dark red almost black eyes). To investigate this unusual condition, the male was mated with 7 virgin females. This mating produced 78 F_1 adults all with normal eyes. The F_1's were allowed to mate with each other and produced 703 F_2 offspring of which 60 were red eyed (37 males and 23 females). The presence of red eyed F_2 females eliminated the red-eyed trait as being sex-linked and recessive (if it was, no red-eyed females would be produced). Various crosses between red eyed and normal eyed F_2 adults are being evaluated in an effort to determine the genetic basis of the red eyed trait. In addition, all adults and nymphs collected in the resistance survey on wild hosts at 72 locations in the fall in the

Delta (discussed previously) were examined for red eyes to see if this trait occurred in nature. A total of 6,661 adults and 4,126 nymphs were examined for red eyes, but none was found. **(G. L. Snodgrass)**

A large plot field test designed to evaluate treatment thresholds currently recommended by the Mississippi Cooperative Extension Service for the control of tarnished plant bugs in cotton, was conducted on a growers farm near Indianola, MS. Unfortunately, plant bug numbers found in the plots during June and July were too low to properly evaluate the test. **(G. L. Snodgrass, W. P. Scott)**

2. Extramural

Continued in cooperative studies to determine the significance of sound production of fire ants. Several types of sound generated by fire ants have been identified. **(L. Lambert, R. Hickling)**

B. *INDICATORS OF PROGRESS:*

1. Publications (Published, In Press, Accepted)

Bell, M. R. 1995 Production and application of a nuclear polyhedrosis virus in the large area management of *Heliothis virescens* and *Helicoverpa zea* (Lepidoptera: Noctuidae). National Annual Meeting of the Entomological Society of America, December, 1995, Dallas, TX. (Abstract)

Bell, M. R. 1995. Effects of an entomopathogenic nematode and a nuclear polyhedrosis virus on emergence of *Heliothis virescens* (Lepidoptera: Noctuidae). J. Entomol. Sci. 30: 243-250.

Bell, M. R. and D. D. Hardee. 1995. Tobacco budworm and cotton bollworm: Methodology for virus production and application in large-area management trials, pp. 857-859. Proc. Beltwide Cotton Prod. Conf.

Burris, E., B. R. Leonard, C. A. White, J. B. Graves, and W. P. Scott. 1995. Evaluation of Fipronil and Imidacloprid (Gaucho 480 and Admire 2F) applied in-furrow in cotton, pp. 918-920. Proc. Beltwide Cotton Prod. Conf.

Elzen, G. W. 1995. Cotton aphid control, 1993A. Arthropod Management Tests. 20: 195-196.

Elzen, G. W. 1995. Cotton aphid control, 1993B. Arthropod Management Tests. 20: 197.

Elzen, G. W. 1995. *Heliothis* response to conventional insecticides and B.t.'s. Proc. 41st Annual Mississippi Insect Control Conf., pp. 13-14. (Abstract).

Elzen, G. W. 1995. Trends in *Heliothis* resistance, 1994. Proc. Beltwide Cotton Prod. Res. Conf., pp. 964-967.

Graves, J. B., G. W. Elzen, M. B. Layton, R. H. Smith, and M. L. Wall. 1995. Budworm/bollworm management: Insecticide resistance and population trends in the mid-south. Proc. Beltwide Cotton Prod. Res. Conf., pp. 136-140.

Hardee, D. D. 1995. Use of novel chemicals in IPM. Proc. United Nation's Food and Agriculture and U.N. Environmental Program Panel of Experts on Integrated Pest Management, Rome, Italy (In Press).

Hardee, D. D. 1995. Resistance management in the Mid South -- cotton aphid: current status as a pest of cotton. Proc. Crop Management Seminar, Cotton, Inc., (In Press).

Hardee, D. D., and M. R. Bell. 1995. Area-wide management of *Heliothis/Helicoverpa* in the delta of Mississippi -- 1994 program. World Cotton Res. Conf., Brisbane, Australia. (In Press).

Hardee, D. D., and G. A. Herzog. 1995. 48th Annual Conference Report on Cotton Insect Research and Control, pp. 725-744. Proc. Beltwide Cotton Prod. Res. Conf.

Hardee, D. D., and E. B. Mitchell. 1995. Boll weevil, *Anthonomus grandis* Boheman: A summary of research on behavior as affected by chemical communication. *In* A Centennial Symposium on the Cotton Boll Weevil. USDA, ARS (In Press).

Hardee, D. D., A. A. Weathersbee, III, J. M. Gillespie, G. L. Snodgrass, and A. R. Quisumbing. 1995. Performance of trap designs, lures, and kill strips for the boll weevil (Coleoptera: Curculionidae). J. Econ. Entomol. (In Press).

Hendricks, D. E., D. W. Hubbard, and D. D. Hardee. 1995. Occurrence of beet armyworm moths in the lower Mississippi River Delta as indicated by numbers caught in traps in 1994. Southwest. Entomol. 20: 157-164.

Hendricks, D. E., D. W. Hubbard, and D. D. Hardee. 1995. Occurrence of beet armyworm moths in cotton-growing areas of the lower Mississippi River Delta as indicated by numbers caught in pheromone traps from April to November, 1994, 802-804. Proc. Beltwide Cotton Prod. Res. Conf.

Hendricks, D. E. and D. W. Hubbard. 1995. Abundance of beet armyworm moths in the cotton-growing region of the lower Mississippi river delta of Mississippi as indicated by captures in pheromone traps-April to November, 1994. Proc. 41st Insect Control Conference, Miss. State, MS pp.10-12 (Abstract). (In Press).

Hendricks, D. E. and D. W. Hubbard. 1995. Abundance of beet armyworm moths in the cotton-growing region of the lower Mississippi river delta of Mississippi as indicated by captures in pheromone traps, Dec. 94 to November, 1995. Proc. 42nd Insect Control Conference, Miss. State, MS. (Abstract). (In Press).

Herzog, G. A., D. D. Hardee, and M. R. Williams. 1995. Highlights of the 48th Annual Cotton Insect Research and Control Conference., 744-745. Proc. Beltwide Cotton Prod. Res. Conf.

Kanga, L. H. B., F. W. Plapp, Jr., M. L. Wall, M. A. Karner, R. L. Huffman, T. W. Fuchs, G. W. Elzen, and J. L. Martinez-Carillo. 1995. Monitoring for tolerance to insecticides in boll weevil populations (Coleoptera: Curculionidae) from Texas, Arkansas, Oklahoma, Mississippi, and Mexico. J. Econ. Entomol. 88: 198-204.

Kanga, L. H. B., F. W. Plapp, Jr., G. W. Elzen, M. L. Wall, and J. D. Lopez, Jr. 1995. Monitoring for resistance to organophosphorus, carbamate, and cyclodiene insecticides in tobacco budworm adults (Lepidoptera: Noctuidae). J. Econ. Entomol. 88: 1144-1149.

Kanga, L. H. B., F. W. Plapp, Jr., M. L. Wall, and G. W. Elzen. 1995. A four year study of resistance to organophosphorus, carbamate, and cyclodiene insecticides in the tobacco budworm in Texas and Arkansas. Southwest. Entomol. 20: 237-246.

King, E. G., R. J. Coleman, L. Wood, L. Wendel, S. Greenberg, A. Scott, J. Roberson, and D. D. Hardee. 1995. Suppression of the boll weevil in commercial cotton by augmentative releases of a wasp parasite, Catolaccus grandis., pp. 26-30. Proc. Beltwide Prod. Res. Conf. Addendum.

Lambert, L. 1995. Registration Certification of insect resistant soybean germplasm D89-9121. Received (1995) certification and assigned registration No. Gp-166 from Crop Science Society of America.

Lambert, Lavone and Jeff Tyler. 1995. An appraisal of insect resistant soybeans. ESA Thomas Say Publ. Series. (In Press).

Laster, M. L. 1995. *Proboscidea louisianica:* An unreported host of *Heliothis virescens* (Lepidoptera: Noctudiae). J. Entomol. Sci. 30: 429-433.

Laster, M. L., and D. D. Hardee. 1995. Intermating compatibility between North American *Helicoverpa zea* and *Heliothis armigera* (Lepidoptera: Noctuidae) from Russia. J. Econ. Entomol. 88: 77-80.

Laster, M. L., and C. F. Sheng. 1995. Search for hybrid sterility for *Helicoverpa zea* in crosses between the North American *H. zea* and *H. armigera* (Lepidoptera: Noctuidae) from China. J. Econ. Entomol. 88: 1288-1291.

Martin, S. H., G. W. Elzen, J. B. Graves, S. Micinski, B. R. Leonard, and E. Burris. 1995. Toxicological responses of tobacco budworm (Lepidoptera: Noctuidae) from Louisiana, Mississippi, and Texas to selected insecticides. J. Econ. Entomol. 88: 505-511.

Roehrdanz, R. L., J. D. Lopez, J. Loera, and D. E. Hendricks. 1994. Limited mitochondrial DNA Polymorphism in North American populations of *Heliothis virescens* (Lepidoptera: Noctuidae). Annals Entomol. Soc. Amer. 87: 856-866.

Scott, W. P., and G. L. Snodgrass. Efficacy of Fipronil and Provado against tarnished plant bugs in cotton, 1994. J. Arthropod Management Tests. (In Press).

Smith, M. T., and D. D. Hardee. Influence of fungicides on development of an entomopathogenic fungus (Zygomycetes: Neozygitaceae) in the cotton aphid (Homoptera: Aphididae). Environ. Entomol. (Accepted 5/1/95).

Smith, M. T. 1995. Evaluation of exotic parasitoid species from areas of *Bemisia tabaci* origin, p. 139. *In* Henneberry, T. J., N. C. Toscano, R. M. Faust, and J. R. Coppedge (eds.), Silverleaf whitefly (Formerly sweetpotato whitefly, strain B): 1995 Supplement to the 5-year National Research and Action Plan. USDA 1995-2, 305 pp.

Smith, M. T. 1995. Recent advances in hickory shuckworm sex pheromone research. Proc. Southeastern Pecan Growers Association, 88: 52-59.

Smith, M. T. 1995. Insect pest management research notes. Pecan Grower 7: 32.

Smith, M. T. 1995. Aphid-Host Plant Interactions. Proc. Second National Pecan Workshop. (In Press).

Snodgrass, G. L., and G. W. Elzen. 1995. Insecticide resistance in a tarnished plant bug population in cotton in the Mississippi Delta. Southwest. Entomol. 20: 317-323.

Snodgrass, G. L., and G. W. Elzen. 1995. Insecticide resistance in a tarnished plant bug population in cotton in the Mississippi Delta. Proc. Beltwide Cotton Prod. Res. Conf., pp. 975-977.

Snodgrass, G. L. A glass vial bioassay for detecting insecticide resistance in adult tarnished plant bugs (Heteroptera: Miridae). J. Econ. Entomol. (Accepted 14 May 1995)

Snodgrass, G. L. Insecticide resistance in a field population of the tarnished plant bug (Heteroptera: Miridae) in cotton in the Mississippi Delta. J. Econ. Entomol. (Accepted 14 May 1995).

Snodgrass, G. L. and G. W. Elzen. 1995. Insecticide resistance in a tarnished plant bug population in cotton in the Mississippi Delta. Proc. 41st Annual Mississippi Insect Control Conf., p.19 (Abstract).

Snodgrass, G. L. 1995. A close look at the plant bug. Crop Protection Management Magazine. March 1995, p. 8.

Snodgrass, G. L. and W. P. Scott. 1995. Seasonal changes in pyrethroid resistance in tarnished plant bug populations in the Mississippi Delta. Proc. Cotton Inc. Crop Management Seminar, Oct.30-31, Memphis, TN.

Solomon, W., L. Lambert, and M. R. Bell. 1995. Susceptibility of five defoliators of soybean to celery looper nuclear polyhedrosis virus. J. Entomol. Sci. (In Press).

Thompson, Tommy E., W. D. Goff, M. Nesbitt, L. J. Grauke, B. W. Wood, M. Smith, and M. T. Smith. 1995. Breeding scab resistance cultivars. Proc. Southeastern Pecan Growers Association 88: 162-167.

Tillman, P. G., and L. Lambert. 1995. Influence of soybean pubescence on incidence of the corn earworm and the parasitoid, *Microplitis croceipes.* Southwest. Entomol. 20: 181-185.

Weathersbee, A. A., III, D. D. Hardee, and W. R. Meredith, Jr. 1995. Differences in yield response to cotton aphids (Homoptera: Aphididae) between smooth-leaf and hairy-leaf isogenic cotton lines. J. Econ. Entomol. 88: 749-754.

Wood, B. W., J. A. Payne, and M. T. Smith. 1995. Suppressing pecan aphid populations using potassium nitrate plus surfactant sprays. HortScience. 30: 513-516.

2. In Manuscript:

Bell, M. R., and D. D. Hardee. Six years of area-wide management of bollworm/budworm with pathogens - what does it mean and where do we go from here. Proc. 1996 Beltwide Cotton Prod. Conf. (In Preparation).

Bell, M. R., and Glynn Tillman. Effect of nuclear polyhedrosis virus on field populations of the beet armyworm in cotton. J. Econ. Entomol. (In Preparation).

Bryan, W. W., D. A. Herbert, Jr., and D. D. Hardee. Evaluation of three oviposition methods, three different host densities, and mortality factors in a M*icroplitis croceipes* rearing program. (In Preparation).

Bryan, W. W. and D. A. Herbert, Jr. The effect of four soil types on depth bored by *Microplitis croceipes* parasitized and nonparasitized *Helicoverpa zea* larvae in the laboratory. (In Preparation).

Bryan, W. W. and D. A. Herbert, Jr. Emergence of *Microplitis croceipes* and its host, *Helicoverpa zea* from four soil types in the laboratory. (In Preparation).

Bryan, W. W. and D. A. Herbert, Jr. The effect of two soil types and cotton plants on depth bored by *Microplitis croceipes* parasitized and nonparasitized *Helicoverpa zea* larvae in the greenhouse. (In Preparation).

Bryan, W. W. and D. A. Herbert, Jr. The effect of three soil types and cotton plants on depth bored by *Microplitis croceipes* parasitized and nonparasitized *Helicoverpa zea* in the greenhouse. (In Preparation).

Bryan, W. W. and D. A. Herbert, Jr. Effect of soil tillage practices on *Microplitis croceipes* cocoon location in the field. (In Preparation)

Bryan, W. W. and D. A. Herbert, Jr. Opportunities for manipulation of *Microplitis croceipes* in first generation *Helicoverpa zea*: A survey of wild and cultivated early season host plants in Virginia. (In Preparation).

Elzen, G. W. Changes in insecticide tolerance in tobacco budworm in 1995. Proc. 42nd Mississippi Insect Control Conf. (Abstract). (Submitted).

Elzen, G. W. Development of resistance to multiple class of insecticides in *Heliothis virescens* (F.) (Lepidoptera: Noctuidae) populations in the U.S. mid-south. Proc. XX International Congress of Entomology. (Abstract). (Submitted).

Elzen, G. W. Control of tarnished plant bug, 1994. Arthropod Management Tests. (Submitted).

Elzen, G. W. Cotton aphid control, 1994. Arthropod Management Tests. (Submitted).

Elzen, G. W. Ovicidal activity trial, 1995. Arthropod Management Tests. (Submitted).

Elzen, G. W. Cotton aphid control, 1995. Arthropod Management Tests. (Submitted).

Elzen, G. W. Control of tarnished plant bug, 1995. Arthropod Management Tests. (Submitted).

Elzen, G. W. Changes in tolerance to insecticides in tobacco budworm populations, 1995. Proc. 1996 Beltwide Cotton Prod. Res. Conf. (In Preparation).

Elzen, G. W. Evaluation of beet armyworm (Lepidoptera: Noctuidae) tolerance to insecticides and response to IGR's. Southwest. Entomol. (In Preparation).

Elzen, G. W. Laboratory evaluation of tarnished plant bug tolerance to insecticides, 1995. Arthropod Management Tests. (In Preparation).

Hardee, D. D., and W. W. Bryan. 1996. Influence of Bt-transgenic and nectariless cotton on insect populations, with special emphasis on the tarnished plant bug, *Lygus lineolaris* (P. de B) (Heteroptera: Miridae). (In Preparation).

Hardee, D. D., and M. L. Laster. 1996. Current status of backcross sterility in *Heliothis virescens* (F.) -- a progress report. Submitted to Southwest. Entomol.

Landram, D., M. T. Smith and W. Hays. Behavioral modeling of *Encarsia formosa* as a parasitoid of *Bemisia argentifolii* (Bellows and Perring) under different temperature regimes. J. Insect Behavior. (In Preparation).

Laster, M. L., D. D. Hardee, and J. C. Schneider. 1995. *Heliothis virescens* (Lepidoptera: Noctuidae) suppression by sterile backcross releases. Submitted to Southw. Entomol.

Scott, W. P., G. L. Snodgrass, and Donnie Adams. Mortality of tarnished plant bugs and boll weevils exposed to Provado and different formulations of Fipronil. Proc. 1996 Beltwide Cotton Prod. Conf. (In Preparation).

Scott, W. P., and F. Cooke. Cost and changes of cotton insect control in the Mississippi Delta. Proc. 1996 Beltwide Cotton Prod. Conf. (In Preparation).

Scott, W. P., G. L. Snodgrass, R. Shaw, and Donnie Adams. 1995. Efficacy of recommended insecticides with/without Buctril herbicide for various cotton pests. J. Entomol. Sci. (Submitted Sept. 1995).

Smith, M. T., and R. Hennessey. Biological evaluation of two strains of *Encarsia formosa* as parasitoids of *Bemisia argentifolii* (Bellows and Perring) under different temperature regimes. Environ. Entomol. (Submitted).

Smith, M. T., S. Galindo, and C. Yonce. Spatial distribution and seasonal dynamics of the hickory shuckworm (*Cydia caryana*). Environ. Entomol. (In Preparation).

Smith, M. T. Spatial distribution and movement of stinkbugs in pecan. J. Econ. Entomol. (In Preparation).

Smith, M. T. Evaluation methods for stinkbug damage in pecan. J. Econ. Entomol. (In Preparation).

Smith, M. T., and D. D. Hardee. Seasonal relationship among cotton aphid (*Aphis gossypii* Glover), the entomopathogenic fungus *Neozygites fresenii* (Nowakowski) Batko, and the parasite *Lysiphlebus testaceipes* (Cresson). Environ. Entomol. (In Preparation).

Smith, M. T., D. Landram, and W. Hays. Behavioral evaluation of *Encarsia formosa* as a parasitoid of *Bemisia argentifolii* (Bellows and Perring) under different temperature regimes. J. Insect Behavior. (In Preparation).

Smith, M. T., R. F. Severson, G. W. Chapman, and R. J. Horvat. Volatiles of the leaflet, rachis and nut of pecan, *Carya illinoensis*: Potential role in habitat and host finding of pecan herbivore and beneficial insect species. J. Chem. Ecol. (In Preparation).

Smith, M. T., C. C. Reilly, and B. W. Wood. Developmental and reproductive performance of the blackmargined aphid (*Monellia caryella* Fitch), the yellow pecan aphid (*Monelliopsis pecanis* Bissell), and the black pecan aphid (*Melanocallis caryaefoliae* Davis), on the North American species of the Juglandaceae: A study of aphid-plant coevolution. Environ. Entomol. (In Preparation).

Smith, M. T., R. F. Severson, C. C. Reilly, and B. W. Wood. Host-plant selection by the blackmargined aphid (*Monellia caryella* Fitch), the yellow pecan aphid (*Monelliopsis pecanis* Bissell), and the black pecan aphid (*Melanocallis caryaefoliae* Davis), on the North American species of the Juglandaceae: A comparative study of foliar cuticular chemistry and host-plant recognition. J. Chem. Ecol. (In Preparation).

Smith, M. T., C. C. Reilly, and B. W. Wood. Developmental and reproductive performance of the blackmargined aphid (*Monellia caryella* Fitch), the yellow pecan aphid (*Monelliopsis pecanis* Bissell), and the black pecan aphid (*Melanocallis caryaefoliae* Davis), on a select group of pecan cultivars. Environ. Entomol. (In Preparation).

Smith, M. T., R. F. Severson, C. C. Reilly, and B. W. Wood. Host-plant selection by the blackmargined aphid (*Monellia caryella* Fitch), the yellow pecan aphid (*Monelliopsis pecanis* Bissell), and the black pecan aphid (*Melanocallis caryaefoliae* Davis), on a select group of pecan cultivars. J. Chem. Ecol. (In Preparation).

Smith, M. T., R. F. Severson, and R. C. Gueldner. Seasonal dynamics of the surface chemistry of pecan leaves, rachis and nut. J. Agric. Food Chem. (In Preparation).

Smith, M. T., R. F. Severson, and R. C. Gueldner. Seasonal dynamics of the whole tissue chemistry of pecan leaves, rachis and nut. J. Agric. Food Chem. (In Preparation).

Smith, M. T., C. C. Reilly, B. W. Wood, and R. Paul. SEM analysis of leaf surface morphology of the Juglandaceae native to North America: Implications in host plant resistance to pecan aphids. Environ. Entomol. (In Preparation).

Smith, M. T., C. C. Reilly, B. W. Wood, and R. Paul. SEM analysis of leaf surface morphology of the a select group of pecan cultivars: Implications in host plant resistance to pecan aphids. Environ. Entomol. (In Preparation).

Snodgrass, G. L. Distribution of the tarnished plant bug (Heteroptera: Miridae) within cotton plants. Environ. Entomol. (In Preparation).

Snodgrass, G. L. and W. P. Scott. Pyrethroid resistance in overwintered and first generation tarnished plant bug populations in the Mississippi River Delta. Proc. 1996 Beltwide Cotton Prod. and Research Conf. (In Peer Review).

Snodgrass, G. L. Sweep net sampling of the tarnished plant bug (Heteroptera: Miridae) in cotton. Environ. Entomol. (In Peer Review).

Tillman, P. Glynn, Jon L. Roberson, and D. D. Hardee. 1995. Disposable cardboard box for rearing/release of *Microplitis croceipes*. Submitted to Southwest. Entomol.

3. <u>Presentations</u>:

Bell, M. R., and D. D. Hardee. "Tobacco budworm and cotton bollworm: Methodology for virus production and application in large-area management trials." Beltwide Cotton Insect Research and Control Conf., San Antonio, TX, January 1995.

Bell, M. R. "Role of diseases in regulation of tobacco budworm population." Mississippi Tobacco Budworm Symposium, Mississippi State, MS, November 1995.

Bryan, W. W., and D. A. Herbert. "*Microplitis croceipes* (Hymenoptera: Braconidae) for control of *Helicoverpa zea* (Lepidoptera: Noctuidae) in soybean and cotton: Investigations for enhanced rearing practices, and opportunities for conservation and augmentation." Southeastern Branch ESA, Charleston, SC, March 5-8, 1995. (Poster presentation).

Bryan, W. W. and D. A. Herbert, Jr. "Survey of wild and cultivated early season host plants of *Helicoverpa zea* in Virginia." ESA National Conference, Las Vegas, NV, December 17-21, 1995. (Poster presentation)

Elzen, G. W. "Trends in *Heliothis* resistance, 1994." Beltwide Cotton Insect Research and Control Conf., San Antonio, TX, January 1995.

Elzen, G. W. "Cotton pest resistance levels." Cotton Consultant Seminar, CIBA, Orange Beach, AL, February 1995. (Invitation).

Elzen, G. W. "*Heliothis* resistance in Mississippi." Bayer Cotton Update, Baton Rouge, Louisiana. October 1995. (Invitation).

Elzen, G. W. "Changes in insecticide tolerance in tobacco budworm in 1995." 42nd Mississippi Insect Control Conf., Mississippi State, MS, November 1995.

Elzen, G. W. "Insecticide resistance - Mississippi Perspective." Mississippi Tobacco Budworm Symposium, Mississippi State, MS, November 1995. (Invitation).

Elzen, G. W. "Efficacy of currently available insecticides against tobacco budworm." Cotton shortcourse, Entomology Session, Mississippi State, MS, December 1995. (Invitation).

Hardee, D. D. "Update on ARS Research with emphasis on pathogens in tobacco budworms and beet armyworms," 22nd Meeting of Mississippi Agricultural Consultants Association, Mississippi State, MS, February 1995. (Invitation).

Hardee, D. D. "Future changes -- Bt cotton, boll weevil eradication, insecticide resistance," ARS-MSU Symposium on Tarnished Plant Bug, Stoneville, MS, March 1995. (Invitation).

Hardee, D. D. "Chemical communication in the boll weevil," Lecture Series on the Significance of the Boll Weevil to Science and Society," Texas A&M Univ., College Station, TX, April 1995. (Invitation).

Hardee, D. D. "Resistance management in the mid-south -- cotton aphid: Current status as a pest of cotton. Cotton, Inc. Crop Management Seminar, Memphis, TN, October 1995 (Invitation).

Hendricks, D. E., D. W. Hubbard and D. D. Hardee. 1995. "Occurrence of beet armyworm moths in the cotton-growing areas of the lower Mississippi river delta as indicated by numbers caught in pheromone traps from April to November, 1994." Beltwide Cotton Conferences, San Antonio, TX, January 1995.

Hendricks, D. E. and D. W. Hubbard. 1995. "Abundance of beet armyworm moths in the cotton-growing region of the lower Mississippi river delta of Mississippi as indicated by captures in pheromone traps, Dec. 94 to November, 1995." 42nd Annual Mississippi Insect Control Conference, Miss. State, MS, November 1995.

Hendricks, D. E. 1995. Role of wild host plants supporting tobacco budworm populations after cotton harvest and mortality due to flooding in the springtime. Mississippi Tobacco Budworm Symposium, Miss. State, MS, November 1995.

Hickling, R., and L. Lambert. "Sounds produced by imported fire ants." Imported Fire Ants Conference, San Antonio, TX, May 1995.

Lambert, L. "Host plant resistance of soybean to insect damage." Department of Biology, Delta State University, Cleveland, MS, April, 1995.

Scott, W. P. "Review of ARS research on the tarnished plant bug." Tarnished Plant Bug Symposium, Stoneville, MS, March 30, 1995.

Scott, W. P. "Effects of Provado in controlling tarnished plant bugs in small plots." Bayer Ag Company, Update on Result of Ag Products, Baton Rouge, LA, October 24, 1995.

Smith, M. T., and R. D. Hennessey. "Evidence of two ecotypes of *Encarsia formosa* Gahan (Hymenoptera: Aphelinidae) parasitizing *Bemisia argentifolii* (Homoptera: Aleyrodidae) on Hibiscus." USDA-ARSThird Annual Review of the Silverleaf Whitefly National Research and Action Plan Meeting, San Diego, CA, January 1995.

Smith, M. T. "Pecan insect pest management: Recent investigations of the hickory shuckworm sex pheromone." 88th Southeastern Pecan Growers Association Convention, Panama City, FL, March 1995.

Smith, M. T. "An update of current pecan pest management research in Mississippi." Mississippi/Louisiana Pecan Growers Conference, Greenville, MS, June 1995.

Smith, M. T., and R. D. Hennessey. "Evidence of two ecotypes of *Encarsia formosa* Gahan (Hymenoptera: Aphelinidae) parasitizing *Bemisia argentifolii* (Homoptera: Aleyrodidae) on Hibiscus." 42nd Annual Mississippi Insect Control Conf.,Mississippi State, MS, November 1995.

Smith, M. T., and R. D. Hennessey. "*Encarsia formosa* Gahan (Hymenoptera: Aphelinidae) parasitizing *Bemisia argentifolii* (Homoptera: Aleyrodidae): Behavioral evidence for two ecotypes. Entomological Society of America Meeting, Las Vegas, NV, December 1995.

Snodgrass, G. L. and W. P. Scott. "Pyrethroid resistance in overwintered and first generation tarnished plant bug populations in the Mississippi River Delta." 42nd Annual Mississippi Insect Control Conference, Mississippi State, MS, November 13-15, 1995.

Snodgrass, G. L. "Contribution of spring host plants to tobacco budworm populations." Mississippi Tobacco Budworm Symposium. Mississippi State, MS, November 15-16, 1995.

Snodgrass, G. L. "Pyrethroid resistance in tarnished plant bug populations in the Mississippi Delta." Seminar sponsored by Bayer Chemical Co., Baton Rouge, LA, October 23-25, 1995.

Snodgrass, G. L. and W. P. Scott. "Seasonal changes in pyrethroid resistance in tarnished plant bug populations in the Mississippi Delta." Cotton Incorporated Crop Management Seminar, Memphis, TN, October 30-31, 1995.

Snodgrass, G. L. and G. W. Elzen. "Insecticide resistance in a tarnished plant bug population in cotton in the Mississippi Delta." Beltwide Cotton Production and Research Conf., Jan. 12-14, 1995, San Antonio, TX (Poster).

Snodgrass, G. L. "Insecticidal control problems with the tarnished plant bug in cotton." Delta Agriculture Exposition, Cleveland, MS, January 24, 1995.

Snodgrass, G. L. "Insecticide resistance in the tarnished plant bug in cotton in the Mississippi Delta." 22nd Annual Meeting Mississippi Agricultural Consultants Association, Mississippi State, MS, February 6-7, 1995.

Snodgrass, G. L. "Biology and control of the tarnished plant bug in cotton in Mississippi." 8th Annual Independent Agricultural Consultants Meeting, Jackson, MS, February 24-26, 1995.

Snodgrass, G. L. "Biology, behavior, and host plants of the tarnished plant bug." Tarnished Plant Bug Symposium, Delta Research and Extension Center, Stoneville, MS, March 30, 1995.

Tillman, P. G., and W. P. Scott. "Susceptibility of *Cotesia marginiventris* to field rates of selected cotton insecticides. 42nd Annual Mississippi Insect Control Conf., Mississippi State, MS, November 14-15, 1995.

IV. PLANNED RESEARCH CALENDAR YEAR 1996:

A. *NARRATIVE:*

1. In-House

Plans for 1996 include investigating and possibly working toward implementation of a large-area pilot test program, with farmer participation, incorporating the application of an entomopathogenic virus on weeds within a large area of crop land in the Mississippi Delta. Two years of testing using a 20 mile diameter demonstrated positive results, and the farmers may now wish to proceed on to the next logical step - a larger area trial program. The primary duties of our unit in an expanded trial would be to contribute expertise and help conduct the test. If the farmers do not wish to invest in a larger trial area, a smaller test area may be used to investigate the interactions of combined management options to increase the level of control within large areas. **(M. R. Bell, G. L. Snodgrass, D. D. Hardee)**

Examine the use of the nuclear polyhedrosis virus from the beet armyworm for control of the pest in various areas of the cotton belt, possibly increasing the effectiveness of control through formulations and application studies, as indicated in small trials in 1995. In conjunction with these studies, we will also investigate the options of obtaining EPA approval for a label of this, and possibly other, baculoviruses by ARS or another farm or research group. **(M. R. Bell)**

As time and funding permit, studies on a new baculovirus having a broad host range (celery looper virus) will continue through laboratory bioassays against tobacco budworms, cotton bollworms, and other available insect hosts, as well as continued studies of the new virus having increased effectiveness against beet armyworms. **(M. R. Bell)**

Continue study with evaluation of the effects of parasitization on lectin and catecholamne levels in corn earworm larvae. **[O. A. Adeyeye (Duquesne University), W. W. Bryan]**

Conduct additional rearing studies using *Microplitis croceipes* and *Helicoverpa zea*. **(W. W. Bryan)**

Conduct field surveys for parasitoids of *Helicoverpa/Heliothis* spp., including early season hosts, Bt transgenic cotton, and non-transgenic cotton varieties. **(W. W. Bryan)**

Monitor wild *Heliothis virescens* during summer using pheromone traps for feasibility of releasing backcross moths in test sites. **(W. W. Bryan)**

Continue to monitor resistance levels in Heliothinae to several classes of insecticides and B.t.'s. Several different bioassays will be used because multifactorial resistance is now present. **(G. W. Elzen)**

Evaluate synergists (known metabolic types and purported insecticide types) on tobacco budworm. **G. W. Elzen)**

Perform field efficacy trials with newly registered and promising insecticides. **(G. W. Elzen)**

The Stoneville Insect Rearing Research Support Group will maintain nine insect species in 1996. These are tobacco budworm, bollworm, soybean looper, beet armyworm, velvetbean caterpillar, boll weevil, greater wax moth, *Cardiochiles nigriceps*, and *Cotesia kazak*. Also, assistance will be given individual scientists in maintaining insects needed for their research. Artificial diet will be supplied in 30 ml plastic cups and 3.8 liter multicellular trays. Efforts will continue to develop lidding for a disposal multicellular larval rearing tray. The training in insect rearing techniques and the transfer of technology provided to industry will continue. As always efforts will continue to produce high quality insects at the most economical price possible. The research of approximately 150 scientists within USDA-ARS, private industry, and state universities will be supported by the work of this group. **(R. L. Ford)**

The insect distribution programs with the Cotton Foundation and the American Soybean Association will continue in 1996. Both programs are expected to be utilized heavily by researchers throughout the United States. Funds provided by these programs will be used to defray insect rearing expenses of the SIML. The egg, pupal, and larval stage of tobacco budworm, bollworm, soybean looper, beet armyworm, and velvetbean caterpillar will be available. **(R. L. Ford)**

Greenhouse and laboratory studies on effect of aldicarb on cotton aphid resistance to insecticides will be expanded to verify previous conclusions. **(D. D. Hardee)**

Various new boll weevil attract-and-kill devices supplied by commercial companies will be evaluated to determine their effectiveness in comparison with commercially available devices and traps. **(D. D. Hardee)**

A boll weevil emergence and movement study (in cooperation with J. R. Coppedge, USDA--ARS, College Station, TX) will be repeated to determine extent of movement of boll weevils after July 1 in close proximity to and 1-3 miles from cotton. **(D. D. Hardee)**

Influence of cotton aphids on ultimate yields of cotton will be studied by spraying cotton 2-3 times beginning prior to squaring, at first 1/3-grown square, and at first bloom. Transgenic and nectariless varieties of cotton will be subplot treatments. **(D. D. Hardee)**

A large-scale study involving the interaction of elcar (NPV), pheromones, and transgenic cotton will be initiated. Sub-plots will be inside or outside the elcar-treated zone, and Mississippi Hills or Delta. **(D. D. Hardee, M. R. Bell)**

Studies through the use of sound and video observations to determine the behavior of foliar feeding insects which damage soybean will be continued. **(L. Lambert)**

Studies will be continued to determine the influence of soybean plant maturity on insect resistance. **(L. Lambert)**

Evaluations of the USDA-ARS soybean germplasm collection will continue in an effort to identify resistance soybean damaging insects. **(L. Lambert, T. Kilen)**

Studies will be continued with soybean to determine the influence of irrigation on the development of soybean looper populations and the subsequent impact on yield. **(L. Lambert, L. G. Heatherly)**

Studies will be continued on the inheritance and development of resistance to foliar feeding insects in soybean and to develop high yielding, insect resistant, soybean cultivars. **(L. Lambert, J. Tyler)**

Will continue to evaluate a gonad-specific virus of the corn earworm. **(L. Lambert, A. Raina)**

Efforts will be continued to identify resistance in cotton to foliar feeding by beet armyworm. **(L. Lambert, W. R. Meredith)**

We will continue in the annual evaluation of the Soybean Regional Host Plant Resistance Nursery for resistance to foliar feeding insects. **(L. Lambert)**

A grant funded through Cotton Incorporated to study plant bug sampling and thresholds will be continued. Recommended thresholds of plant bugs will be sampled by drop cloth, sweep net, and visual methods. **(W. P. Scott, G. L. Snodgrass)**

Spray table studies will continue to evaluate Fipronil formulations on plant bugs and boll weevils. An EUP on Fipronil will allow further evaluation in larger plots. Provado will also be evaluated in large field plots. **(W. P. Scott, G. L. Snodgrass)**

In-furrow, seed, and sidedress studies will be continued to further evaluate these particular treatments on control of early season cotton pests and yield. **(W. P. Scott)**

Spray table tests to evaluate the various metabolites of Fipronil on plant bugs and boll weevils will be conducted. **(W. P. Scott, G. L. Snodgrass)**

Investigations to determine the utility of a trap cropping system designed to intercept migrating stinkbug species as they move from soybean and other host plants to pecan in late season will be continued. Replication of the 1995 tests will be performed in order to: (1) validate trap crop efficacy in reducing stinkbug damage; (2) validate the damage assessment methodology; and (3) verify and/or refine the monitoring method for timing insecticide application of stinkbugs in the trap crop. Efforts will also be made to publish the migration data regarding the movement of stinkbugs into the orchard, as well as the data regarding cultivar preference. **(M. T. Smith, G. L. Snodgrass, B. Horton, T. Jenkins, M. Hughs, T. Winters)**

Research investigations of mating disruption will be repeated in 1996 in order to validate the 1995 data, but with the additional objective of improving the method of application/deployment of the mating disruptant, as well as methods to minimize its cost. This will include the evaluation of a sprayable formulation relative to the traditional spirals. Efforts will also be made to analyze and publish

the seasonal and spatial distribution data, coupled with the climatic data. Basic questions regarding mating disruption may also be pursued. **[M. T. Smith, C. Yonce (USDA-ARS), S. Galindo (pecan grower), J. White (Ecogen)]**

Insect:plant:parasitoid interactions of the Silverleaf whitefly, *Bemisia argentifolii,* will be continued. These will include: (1) continuation of the state-wide survey of whitefly and associated parasitoid species in Mississippi; (2) continued efforts towards the joint research program with Dr. Regina Vilarinho de Oliveira (EMBRAPA, CENARGEN, Brasilia, Brazil), where the primary object is to explore for and evaluate New World parasitoid species for control of *B. argentifolii;* and (3) genetic evaluation of the 4 *E. formosa* strains in order to develop potential markers that may be used to differentiate these strains, which in turn could be utilized in monitoring their genetic stability as it relates to parasitoid efficacy (.Drs. C. LeVesque and T. Perring (UCR). Efforts will be made to analyze and publish the current data on *Encarsia formosa* strains in relation to temperature and host plants. **(M. T. Smith)**

As time permits, research of the pecan weevil pheromone and spatial distribution will continue. Additional volatile collections, and EAD and chemical characterization will be performed, as well as field evaluation of various chemistries (insect and/or host odors) for attractancy to the weevil. The second year of intensive weevil trapping in two orchards should provide very useful information with respect to predictability of weevil density via crop load two years hence. Additional information will be obtained on the efficiency of the 'Tedders trap' as a method for direct control of the pecan weevil. Efforts will also be made to develop a trap design which takes advantage of the weevil's aggregation behavior. **(M. T. Smith, G. Greis, H. Pierce, F. Taylor)**

Research may be conducted to evaluate several entomopathogenic nematodes for control of the pecan weevil. **(M. T. Smith, R. W. Martin (Biosys), J. Kuhre)**

Analysis of leaf chemistry of each Juglandaceae species and pecan cultivar will be continued. **(O. T. Chortyk, M. T. Smith)**

SEM analysis of the potential role of leaf surface and/or internal morphology in host plant resistance among the Juglandaceae species and the various pecan cultivars will be completed. **(M. T. Smith, Rex Paul)**

Development of an artificial diet bioassay method for evaluation of phytochemicals (natural products) isolated from the various non-preferred or unsuitable Juglandaceae species and/or pecan cultivars will be continued. **(M. T. Smith)**

Investigations to elucidate the mechanism(s) which govern the host specificity of *M. caryella, M. pecanis* and *M. caryaefoliae* among the hickory and walnut species native to the United States, as well as among the pecan cultivars, will be conducted utilizing grafted plants of each Juglandaceae species and pecan cultivars. **(M. T. Smith, C. C. Reilly, B. W. Wood)**

Insecticide resistance monitoring will be conducted in 1996 using a discriminating dose (15 µg of permethrin) glass vial bioassay and plant bugs collected from wild hosts at 72 locations in the Delta during April and May 1996. Bugs from wild hosts at these same locations will then be tested again in August and September, and results from the 2 time periods compared to results from 1995. This work is part of a Mississippi Cotton Incorporated Grant received for 1995. **(G. L. Snodgrass, W. P. Scott)**

A large field experiment will be conducted using cotton in a commercial field. The experiment is designed to test treatment thresholds and associated sampling methods used to determine them (as recommended by the Mississippi Cooperative Extension Service) to see if they work. The work is part of the grant listed in the preceding paragraph. **(G. L. Snodgrass, W. P. Scott)**

The red eyed plant bug colony will be tested during the winter to try and determine the genetic basis for the trait. Fitness of the red eyed bugs will be studied by determining adult longevity, average egg production per female, percent egg hatch, nymphal developmental time, and percent survival of nymphs. These parameters will be compared to the same ones determined for a normal eyed laboratory colony. Responsiveness of red eyed and normal eyed bugs to different wavelengths of light will be compared to determine if vision in red and normal eyed bugs is the same. If the red eyed bugs are as fit as normal eyed ones, the red eyed colony could be used for movement studies in cotton. Adults and nymphs collected in the resistance study at 72 locations in the Delta in the spring and fall of 1996 will again be examined for red eyed individuals. **(G. L. Snodgrass)**

2. Extramural

A test will be conducted to evaluate the persistence of baculovirus on various crops as well as early season hosts of the tobacco budworm and cotton bollworm and evaluate the relationship of persistence to the epizootic potential of the pathogen. These tests will be conducted in cooperation with the University of Arkansas. **(M. R. Bell)**

Cooperative studies (with the National Center for Physical Acoustics, University of Mississippi, Oxford) to determine the significance of sound production of fire ants will be continued. **(L. Lambert, R. Hickling)**